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Original Research

Analysis of heart rate variability and accelerometry in patients following surgery for the treatment of gastrointestinal cancer

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Abstract

Background: Gastrointestinal cancer is the most prevalent form of cancer worldwide. Surgical treatment interferes with functionality and increases the length of hospital stay. However, studies have shown that early mobilization reduces the length of hospital stay. **Aim:** To determine the cardiovascular safety and intensity of an adapted protocol for early mobilization in patients following surgery for the treatment of gastrointestinal cancer. Methods: An observational, cross-sectional study was conducted with 24 individuals: 15 in the case group (cancer patients in the post-operative period) and nine in the control group (hospitalized patients without cancer). All participants were submitted to a standardized early mobilization physiotherapeutic protocol. A portable heart rate monitor and accelerometer were used to obtain data on heart rate variability (HRV), analyzing the variables 'interval between consecutive beats' (RR), 'mean heart rate' (HR), 'standard deviation from mean of all normal RR intervals' (SDNN), 'square root of mean of square of differences between consecutive RR intervals' (RMSSD), 'number of RR intervals' (NN50) and 'percentage of adjacent RR intervals with difference in duration greater than 50 ms' (pNN50), and the intensity of physical activity (IPA), analyzing metabolic equivalents (METS), before and after the intervention. Data analysis involved the Student's t-test for the comparison of data with parametric distribution and the Mann-Whitney U test for variables with non-parametric distribution. **Results:** No statistically significant differences in energy expenditure or IPA percentages were found between groups. Moreover, no significant difference in HRV occurred in the case group, whereas differences in RR, HR and pNN50 variables were found in the control group. **Conclusions:** Early mobilization for patients following surgery for the treatment of gastrointestinal cancer can be performed without increasing HRV and with energy expenditure and IPA similar to those found in patients without cancer.

Keywords: Gastrointestinal Neoplasms; Accelerometry; Early Mobilization; Physiotherapy techniques; Heart rate determination.

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How can the results of this study be used in clinical practice

- The results of this study will allow a safer execution of early mobilization by professionals who work in the treatment of this population.

Introduction

Cancer of the gastrointestinal tract is the most prevalent form of cancer worldwide and the most common among older adults[1]. The affected organs associated with the highest mortality rates are the stomach, colon, rectum and esophagus[2,3]. Surgical treatment is indicated but can lead to reductions in functionality and the level of physical activity (PA) as well as fatigue and prolonged hospital stay[4-6].

Several cancer treatments increase cardiovascular risk factors, and chemotherapy has one of the most potentials for cardiotoxicity. Among the adverse effects of chemotherapy, myocardial aggression with systolic ventricular dysfunction and heart failure stand out, leading to ischemia or changes in blood pressure, instability of the pericardial fluid balance, increasing the risk of cardiac arrhythmias. The signals/symptoms and pathophysiology of cardiotoxicity depend on the type of chemotherapy agent[7,8].

There is evidence that PA in the pre- and post-cancer treatment periods is safe and associated with improved physical functioning and quality of life as well as a reduction in cancer-related fatigue[9,10]. Moreover, some studies have shown that early mobilization (EM) in the postoperative period following surgery for the treatment of colon cancer reduces the length of hospital stay[11]. Other benefits of EM include an improvement in lung function, the prevention of muscle hypotrophy and orthostatic hypotension, an improvement in the cardiovascular response to exercise, a faster return of adequate intestinal function and a reduced risk of venous thromboembolism[11-16].

Considering the risks to which patients are exposed in the postoperative period, EM is essential to the recovery of these individuals. However, valid data on cardiovascular safety and the level of intensity of this activity are needed, especially for cancer patients. For such, an accelerometer and heart rate monitor can provide objective data on the intensity of PA, energy expenditure and heart rate variability (HRV)[17,18].

Therefore, the aim of the present study was to determine the cardiovascular safety and intensity of an adapted EM protocol for patients in the post-operative period following surgery for the treatment of gastrointestinal cancer. Accelerometer and heart rate monitor instruments will be used to achieve the aim of the study.

Methodology

Design

An observational, cross-sectional study was conducted at the surgical ward of the João de Barros Barreto University Hospital between June and September 2019. This study received approval from the Human Research Ethics Committee of the hospital (certificate number: 3.416.326) and was conducted in accordance with the research norms involving human subjects stipulated in Resolution 466/12 of the Brazilian National Health Board.

Participants

The case group consisted of cancer patients from the 1st to the 7th postoperative day following the surgical removal of malignant tumors of the gastrointestinal tract, admitted to the hospital, aged 18 years or older and who agreed to participate in the study by signing a statement of informed consent. The control group consisted of patients admitted to the hospital without a diagnosis of gastrointestinal cancer matched for age and sex to the group of cases and who agreed to participate by signing a statement of informed consent. This choice was based on the definition of nested case and control groups with selection through a predefined cohort. For each case, a control is randomly selected with pairing for the confounding effect of time. The choice of the control is based on the non-diagnosis of the disease in question, but control subjects may have other adverse health conditions and the group does not necessarily need to be composed of healthy individuals[19]. The exclusion criteria were an inability to start or end the protocol and having other limiting conditions that would interfere with data collection, such as respiratory failure, uncontrolled cardiovascular disease, unstable angina, severe systemic diseases recent embolism, uncontrolled diabetes or orthopedic conditions that would limit the application of the mobilization protocol.

Instruments

Accelerometer

The Actigraph GT3X tri-axial device was used. This tool calculates energy expenditure and time spent on activities of different intensities. It also enables the determination of the sum of vector magnitude movements along three axes and has proved reliable for measuring the level of PA in adults during activities of daily living[20-22].

Heart rate monitor

The portable Polar® S810 (Polar Electro, Kempele, Finland) was used, which has a sampling frequency of 1000 Hz[23,24]. This equipment has been validated to capture the beat-by-beat heart rate for the analysis of HRV.

Evaluation form

A form was used for the collection of the following data: name, age, sex, type of cancer, type of surgery, place of surgery, other diseases (arterial hypertension, diabetes, allergies, infections, etc.) and vital signs as well as the scores on the modified Borg scale, visual analog pain scale and Karnofsky Performance Status (KPS) scale. The KPS scale ranges from 0 to 100, with higher scores denoting less impairment due to disease[25,26]. Evaluation was performed by two different individuals.

Free and informed consent

The term was initially composed of project information, main objectives, followed by risks and benefits and finally the patient's signature. Regarding the risks, it was included the possible breach of confidentiality, possible side effects of the physical exercise protocol, and inconvenience during the evaluation process; the researchers were held fully responsible, and whatever was necessary was done to alleviate the situation. The benefits of the research included an increase in the scientific community, through articles and works published in the media, knowledge about the evidence of the executed protocol and the instruments used, thus expanding the theoretical framework of the area involved. Above all, it would bring benefits to cancer patients receiving physical therapy treatment.

Intervention

Data collection was performed in a single one-hour session. Vital signs were measured at three different timepoints: 20 minutes before, during and 20 minutes after the protocol. The accelerometer and heart rate monitor were used continuously throughout the data collection period. The physiotherapeutic protocol was adapted from Morris et al.[27]. A cycle ergometer was used for five minutes for the lower limbs and upper limbs, followed by elbow flexion, elbow extension and horizontal shoulder abduction performed in two sets of 10 repetitions with light elastic band resistance. Both the case and control groups underwent the same protocol.

Statistical analysis

Data analysis involved the Student's t-test for the comparison of data with parametric distribution and the Mann-Whitney U test for variables with non-parametric distribution. The level of significance was set to 5% ($p < 0.05$) for the rejection of the null hypothesis.

Results

A total of 24 individuals were included in the study: 15 in the case group (patients in the postoperative period after surgery for the treatment of gastrointestinal cancer) and nine in the control group (hospitalized patients without cancer). Table 1 displays the demographic and clinical characteristics of the groups.

Table 2 shows the mean energy expenditure in METS and median percentage of intensity during the intervention. No statistically significant differences were found for these variables between the two groups.

Table 3 displays the variables related to HRV in the time domain before and after the intervention. No significant difference in HRV occurred in the case group, whereas differences in RR, HR and pNN50 variables were found in the control group.

Table 1. Demographic and clinical characteristics of case and control groups.

Characteristics	Case (n = 15)	Control (n = 9)
Sex		
Female	7 (46.6%)	3 (33.3%)
Male	8 (53.3%)	6 (66.6%)
Age (mean and standard deviation)	53.2 ± 14.8	55.4 ± 10.2
Type of cancer		**Inpatient Diagnosis**
Gastric	6 (40%)	Umbilical hernia (n = 3; 33.3%)
Pancreatic	2 (13.3%)	Gallstones (n = 3; 33.3%)
Hepatic	1 (6.6%)	Hepatic cirrhosis (n = 1; 11.1%)
Intestinal	2 (13.3%)	Thoracic Trauma (n = 1; 11.1%)
Rectal	4 (26.6%)	Erysipelas (n = 1; 11.1%)
KPS	70 (IIQ: 60 – 80)	80 (IIQ: 80 – 90)

KPS (median and interquartile range [IIQ])

Table 2. METS and percentages of PA intensity in case and control groups.

Variables	Case (n = 15)	Control (n = 9)	p-value
METS	1317.3 ± 386.9	1479.4 ± 594.3	NS
% Inactivity	50	40	NS
% Light	40	45	NS
% Moderate	14	13	NS
% Vigorous	0	2	NS

METS: metabolic equivalent of task (mean and standard deviation); Intensity percentages (median); NS: non-significant.

Discussion

The present study investigated HRV and PA level in patients hospitalized in the postoperative period of gastrointestinal cancer in view of the scarcity of published articles addressing this topic. No significant changes in HRV were found after the exercise protocol compared to the pre-intervention period. Moreover, no significant differences were found in the percentage of physical inactivity, light, moderate or vigorous exercise between groups. Therefore, the proposed protocol is safe for this population. Thraen-Borowski et al.[10] suggest that PA is safe during and after cancer treatment and can lead to improvements in physical functioning and quality of life as well as a reduction in fatigue in certain types of cancer.

Table 3. Variables related to heart rate variability in case and control groups (intragroup evaluation).

Variables	Case (n = 15)		p-value	Control (n = 9)		p-value
	Before	After		Before	After	
RR	801.3 ± 151.2	677.5 ± 110.5	NS	780.1 ± 103.2	656.6 ± 93.5	<0.05
HR	77.4 ± 15.9	90.5 ± 13.6	NS	78.1 ± 9.7	93.2 ± 13.6	<0.05
SDNN	344.4 ± 536.7	134.5 ± 98.5	NS	380.7 ± 481.4	172.7 ± 112	NS
RMSSD	452 ± 721.8	181 ± 140.2	NS	472.9 ± 623.3	217.2 ± 142.7	NS
NN50	61.1 ± 78.4	75.5 ± 88.2	NS	28.5 ± 28.4	61.8 ± 63.3	NS
pNN50	35.6 ± 32.4	44.6 ± 34.7	NS	30.5 ± 23.1	19.8 ± 17.7	<0.05

Student's t-test significant alpha level.RR: interval between consecutive beats; HR: mean heart rate; SDNN: standard deviation from mean of all normal RR intervals; RMSSD: square root of mean of square of differences between consecutive RR intervals; NN50: number of RR intervals; pNN50: percentage of adjacent RR intervals with difference in duration greater than 50 ms; NS: non-significant.

The American Cancer Society recommends at least 150 minutes per week of moderate aerobic and strengthening exercises for cancer patients[28]. However, it is necessary to start training with less intensity and duration, followed by a gradual intensification based on the patient's functional capacity and comorbidity status[29]. The measurement of PA is relevant to assessing the effectiveness of interventions to increase PA levels in cancer patients. According to Broderick et al.[30], there is no consensus regarding the minimum number of valid monitoring days; the period should not be too uncomfortable for the patient but should be long enough to portray the usual level of activity.

Cancer patients have a greater tendency towards immobilization due to pain, fatigue and psychological weakness, leading to restrictions to exercise. In the hospital setting, there are even more restrictions to PA due to the limited space as well as the patients' lack of recognition regarding the benefits of exercise. Thus, counseling by the healthcare team is necessary to make individuals aware of the advantages of staying active in the hospital[31,32].

Heart rate can be used to measure daily energy expenditure due to the linear relation between these variables over a wide range of activity levels. Chemotherapy can increase HRV due to its effect on autonomic function[30]. SDNN is a variable that reflects general sympathetic and vagal activity, while RMSSD mainly reflects sympathetic activity. In the present study, reductions in SDNN and RMSSD were found in the cancer patients before and after physical exercise. Indeed, patients in the postoperative period often exhibit changes in sympathetic-vagal balance, decreased HRV and sympathetic hyperactivity due to surgical stress, which can last through the first month after surgery[33].

Mostarda et al.[34] investigated the effects of short-term physical training on cardiorespiratory fitness and autonomic modulation in women with breast cancer undergoing adjuvant therapy. The exercises performed at the hospital consisted of aerobic, resistance and flexibility training performed at a frequency of three times a week on non-consecutive days for four weeks. The authors found that women with breast cancer had autonomic dysfunction and less tolerance to exercise compared to the control group. SDNN, RMSSD and RR values were lower in the cancer group after the protocol. However, this situation had changed after one month of intervention, as demonstrated by the similar results on the cardiorespiratory test and HRV between groups. A similar population was evaluated in another study with an eight-week intervention, in which an increase in SDNN and RMSSD was found in the experimental group compared to the control group (no intervention), demonstrating that exercise increases the general activity of the autonomic nervous system[35].

The present findings reveal that despite the lower functionality compared to the control group, cancer patients were able to perform physical exercises with energy expenditure equivalent to that of the other patients, demonstrating that the diagnosis itself did not interfere decisively with this variable. Moreover, there was no significant change in HRV. One study reported reductions in muscle strength and functional capacity in the postoperative period, when recovery depends on several factors. The reduction of surgical stress, enteral nutrition and early mobilization are important interventions that improve fatigue and functionality. The aim of patient mobilization on the first postoperative day following upper gastrointestinal resection is the acceleration of physical functioning and a reduction in the occurrence of postoperative and pulmonary complications. Indeed, remaining bedridden for long periods is known to exert a negative impact on physical aspects[5].

The scientific evidence on this topic is limited, but researchers agree that the population with neoplasia tends to be more inactive compared to the healthy population, which underscores the importance of interventions designed to promote patient mobilization during hospitalization to improve PA levels[36]. The present findings demonstrate that the proposed protocol is safe from the cardiovascular standpoint and physical therapy should be strongly encouraged for these individuals

This study had some limitations that need to be considered. There were not enough patients in the control group to match the cases according to the age and sex criteria, which explains the difference in the sample size of the two groups. Moreover, administrative problems occurred at the hospital during the study period, resulting in the non-admission of new patients and a reduction in the number of surgeries, which had a negative impact on the sample size.

Conclusion

The present results demonstrate that early mobilization does not increase HRV and can be safely performed in patients in the postoperative period following surgery for gastrointestinal cancer treatment. Moreover, no statistically significant differences were found in energy expenditure or PA intensity between the cases and controls during the protocol, despite the lower level of functionality in patients who composed the case group. It is hoped that this work can pave the way for further research addressing early physical activity in patients hospitalized for cancer treatment.

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Conflict of interest

None.

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Author contributions

MCVA: Conceptualization of the study; Funding acquisition; Writing, revising and/or editing the manuscript; DCSN: Conceptualization of the study; Funding acquisition; Writing, revising and/or editing the manuscript; LMTN: supervision, analysis and/or interpretation; JFD: supervision, analysis and/or interpretation; AACS: supervision, analysis and/or interpretation; LELB: analysis and/or interpretation and revising and/or editing the manuscript; SRC: Conceptualization of the study; Data acquisition, supervision, analysis and/or interpretation; revising and/or editing the manuscript.

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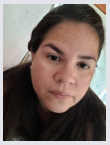

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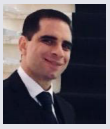

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